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Pierre Rolin, Denis Moalic, Rémi Badonnel, Olivier Berger, Jihane Fouzai

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Collection of MOOC to Create Digital Programs

Pierre ROLIN
IMT, France,
Pierre.rolin@imt.fr
Denis Moalic
IMT Atlantique, France,
denis.moalic@imt-atlantique.fr
Rémi Badonnel
Université de Lorraine, LORIA / INRIA, France
remi.badonnel@loria.fr
Olivier Berger
Télécom SudParis, France
olivier.berger@telecom-sudparis.eu
Jihane FOUZAI
Laboratoire BONHEURS, Université Cergy-Pontoise, France
jfouzai@gmail.com

Abstract
After the pioneering age, IMT is now entering the development and professionalization phase. The purpose of this paper is to present the development of a collection of MOOC in the area of Networks – Telecommunications, how those contents are designed and used in programs for students and professionals

The creation of a full on line degree, bachelor or master, requires the availability of a large number of courses, sharing similar rules of design (length, structure…) and consistent vocabulary. FLIRT1 project purposes were to create a collection of on line lectures in a common technical domain (telecommunications). This collection provides now a solid basis to create education programs either for initial education and lifelong learning context to experiment revenue generation from MOOC and business model [1]. This paper provides design rules, use cases and figures about first programs experimentation.

Keywords: lifelong learning, on-line education, mooc, spoc, telecommunications

1. IMT context

IMT (Institut Mines-Télécom), a network of French graduate engineering schools, is a public institution dedicated to higher education, research and innovation in engineering and digital technology. Always attentive to the economic world, IMT combines academic legitimacy with strong corporate relationships.

[1] Project supported by ANR program investissements d'avenir – FLIRT stands for Formations Libres et Innovantes dans les Réseaux et Télécoms – Free and Innovative Courses for Networks and Telecommunications)

Focusing on key transformations in digital technology, industry, energy and education, IMT trains the engineers, managers and PhDs who will play an active role in the major changes of the 21st century.

13,660 students are studying in Master of Science in Engineering, Master of Science, Master in Management, Executive MBA and PhD. IMT is strongly involved in the production of MOOC in French and English languages. Since 2013, 45 MOOCs have been produced and broadcasted mainly on 2 platforms: FUN (France Université Numérique) and EdX.org. Scientific domains covered by the MOOCs are Networks – Telecommunications (subject of this paper), Sciences for engineers, IT and programming and Digital, energy and industrial transitions.

MOOCs are a pillar of learning transformation at IMT in Graduate programs. MOOCs are currently used in the framework of core curricula in engineering and management courses.

Lifelong learning programs, mainly followed by professionals and job seekers, MOOCs are increasingly used by companies: they regularly use this kind of flexible training method to train staff members by recommending a MOOC or offering them as a SPOC (Small Private Online Course).

2. Producing a collection

Networks and telecommunications fields are historical education domains of 5 IMT engineering schools for developing professional skills. Although MOOCs have a similar purpose as classical courses (acquiring knowledge and skills), pedagogy must be adapted to on line learning. FLIRT[1] project, funded by ANR[2] from 2016 to 2020, aims at developing a collection of contents, in the form of MOOC, so that consistent on line cursus can be proposed to students and professionals in lifelong learning can be evaluated.

2.1. Common pedagogical framework

Firstly the project has designed a common pedagogical framework applicable to all MOOC produced. Each MOOC implements 3 on line activities to develop:

Knowledge: mainly based on video lectures to establish knowledge and quiz to enforce it and evaluate. Theoretical concepts are developed, vocabulary is defined and models (mathematical …) are described and explained.

Practical application: the associated skills are developed through case studies applying knowledge to real cases. Learner has to apply his/her knowledge to solve a problem, evaluate a situation and propose a solution…

Know how: these skills development are based on labs to apply knowledge inside “equipment”. Learner has to setup, configure and measure a described situation.

Professionals’ skills are developed through the practical and know-how activities.

A general structure for each lecture has been defined has followed:

Duration or organization: 5 to 6 chapters (or week). A typical chapter (or week) consists in 4 to 7 lectures, a use case activity and an on line laboratory activity (e.g., simulation).

[2] Agence Nationale de la Recherche program Investissements d’avenir.

The student workload for the whole course activities is about 25 hours (around 5 hours per chapter) which roughly correspond to 1 ECTS (provided the student has the appropriate pre-requisites).

Each MOOC contains 2 sections common to all MOOC in the collection

First section: contains personal questions (who are you, motivations…) useful to analyze student expectations, personal presentation to other students in a dedicated forum, pedagogical team presentation, a prerequisite Quiz and recommendations about course organization, workload, skills targeted by the course …

At the end a: "Your opinion" section queries about level of satisfaction and questions about skill level achievement before and after the course.

Most teachers implied in the project produced their very first on line lecture. The project also recommends the building of multi-teachers/schools teams. This has many advantages: less work-load for each teacher; benefit from teacher best expertise (practice) on each issue; content reuse by teachers in their traditional lectures and also increase teachers skills to on line education (production and use). As a consequence managing the pedagogical team and vocabulary consistency are two critical issues. Each MOOC has a scientific leader, managing the MOOC production and the support of a pedagogical engineer (mastering the platform and video production).

2.2. Common "edition" framework

While different universities and partners are associated to produce MOOCs in the project, is it important to ensure consistency among MOOCs. Thus, several tools and processes have been set up, to guide and help MOOC producers in their way to develop MOOCs.

A production process and chart rules to guide teachers work have been produced. Charting rules are based on a PowerPoint framework defining a common look and feel, a MOOC logo and text size so as to be easy to read during video and how teacher video can be incrusted (Figure 1).

Look & feel is important has it signs visually the collection in each video. A graphical charter has also been develop and provided to video editors and teachers.

The PowerPoint model can be directly used by professor and given to the video production. It has been recommended that each video sequence stay below 7 minutes and focus on one or two concepts maximum.

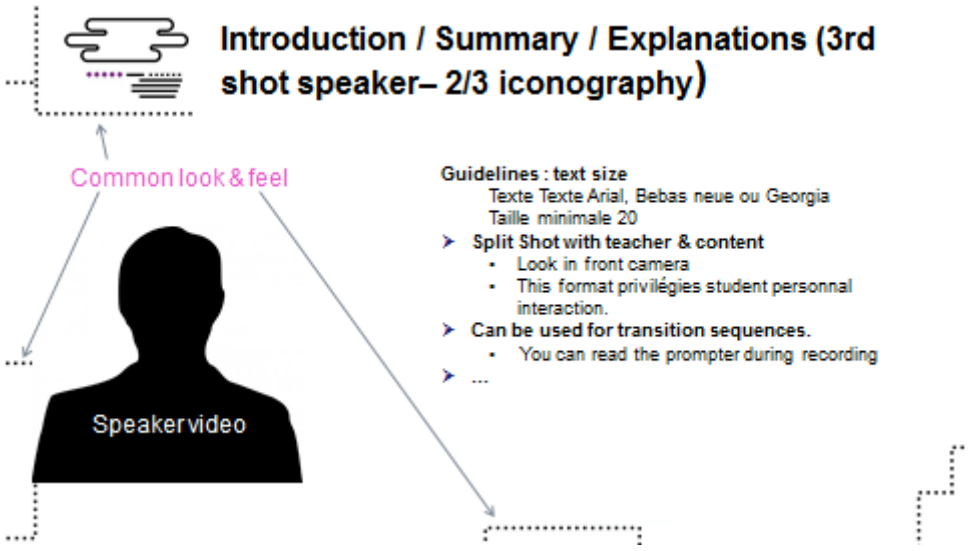


Figure 1 Recommendation example

3. Feed back to pedagogical team

A critical issue for professors in on line course is to know what learners are doing. Do they progress? Are they satisfied? Where do they spend time or get blocked? The forum provides a feeling about learners' difficulties but very few students are posting on the forum [2]. According to our experience this is less than 10% of active[3]students in public MOOC and barely used in SPOC. FLIRT project has developed tools to track and manage learners' progress and behavior.

3.1. Following students

MOOCpilot [4] tool, developed within the project, collects periodically course grades and present the result in graphical form [3].

The graph (Figure 2) represents the exercises' success rate. Columns represent exercises. One column contains all learners who completed this exercise. It is made up of several groups representing the learners' distribution based on their results (below 0.25, from 0.25 to 0.5, from 0.5 to 0.75, over 0.75). This provides information about where student have difficulties (grades below 50%) and how many have done each exercise (one exercise per column).

3.1.1. Diligent learners evaluation

[3] An active or started student has got a grade in at least one graded exercise. There are usually much less active students than enrolled students.

4 MOOCpilot is free software available on Github the development platform for open source.

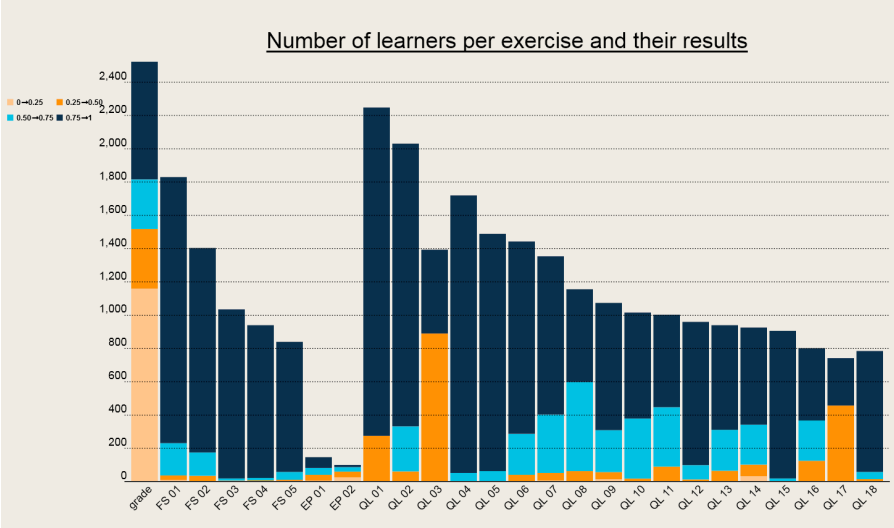


Figure 2 Students progress and results quality.

We define as “diligent learners” (one can also say assiduous) students that did the first graded exercise in week 2 and week 1 exercise(s). This criterion is useful as one knows that a strong proportion of learners drop out during the first week. The “diligent learners” proportion that complete the course, obtains the required global grade for success, is a significant MOOC quality indicator.

The graph (Figure 3) displays the number of learners performing each exercise, based on when they perform them. Lines give exercises’ name. Column Total give how many did exercises cited on line, columns C1, C2,… give grades collection date and how many did the exercises during period span (data collection date) C1-C2, C2-C3…. One bubble contains number of learners who completed this exercise. When browsing over each bubble, percentage enrolled students and active students’[5] percentage are given. On Figure 3 the first graded exercise in week 2 is ES02 also reading bubble (Column Total, Line ES02) gives “diligent learners” number and percentage.

[5] An active or started student has got a grade in at least one graded exercise.

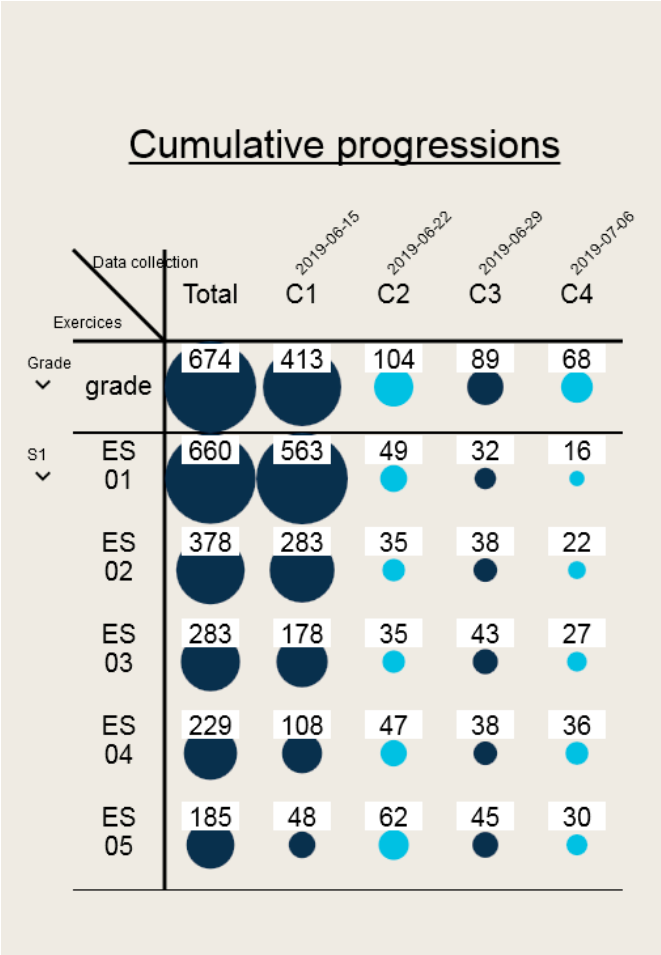


Figure 3 : Temporal progression also called cumulative

As an example on figure 3 above: for exercise “ES02”

- 378 learners took the exercise in total.
    - 283 of them took it before data collection date “C1” (i.e., 2019-06-15),
    - 35 of them took it between data collection date “C1” (i.e., 2019-06-15) and C2 (2019-06-22)
    - Etc.

MOOCpilot measures many other criteria, including forum performance (number of posts, unanswered questions, most active learners, etc.), individual progression, students list that did an exercise. Interested reader will find in [PLA18] more information’s.

3.1.2. MOOC global evaluation

In order to compare different sessions of the same MOOC or different MOOC five indicators are followed (Figure 4). In a MOOC the enrolled learners’ proportion that does a graded exercise, named started or active or students, in the MOOC is always low. In this example this was only 22% and those that continue after first week, diligent students, is even lower.

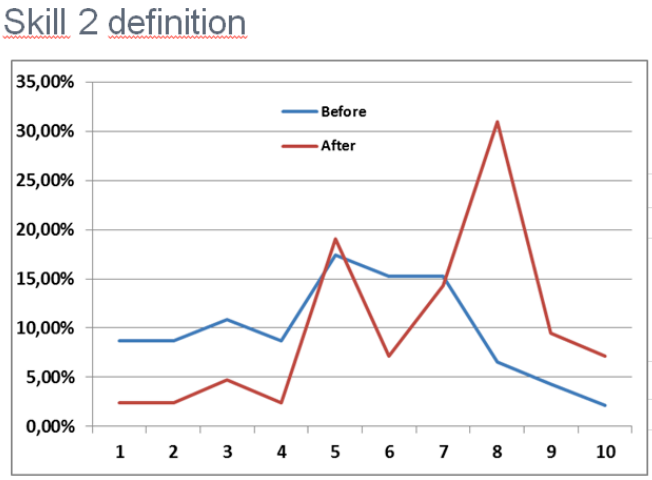
Successful students have a global grade higher than the threshold defined for the MOOC. Figure 3 can be computed with a threshold, then line grade provides directly successful students number and percentage.

Date	Course end	
Enrollments	10246	Including unregistred
% started	22 % 2248	Those that have responded to the first graded exercise (first Week)
% diligent	14 % 1443	Starded that have responded to the first graded exercise in thesecond Week
% success	8,9 % 911	Those that have a global grade > successful rate required
% diligent success	100% 911	Diligent that have a ,lobal grade > successful rate required

Figure 4: Common indicators followed

3.2.Skill achievement

The final QUIZ asks students to scale their perceived skills level mastering before and after the MOOC. Each student evaluates its personal skill level in the range [0, 10]. The Figure 5 shows students responses synthesis for MOOC PRD[6] session 8 (spring 2019). A graph shows response definition and an average is computed. MOOC PRD session 7 (Autumn 2019) is also given. One can observe that for two learners' population, temporally separated, average gain values are pretty close.



PRD8

C_{before}	C_{after}	Average gain
4,91	6,74	1,82

PRD7

C_{avant}	$C_{après}$	Gain moyen
3,38	5,31	1,93

Figure 5: Skill 2 personal evaluation

[6] Principe des Réseaux de Données (Data Networks Essentials)

As an example for figure 5: for skill 2 targeted by the MOOC PRD8, skill mastering perceived by learners is

- 4,91 before taking the MOOC,
- 6,74 after the MOOC,
- Meaning a gain of 1,82 points out of 10.

4. Building cursus

FLIRT project includes more than 10 courses (Figure 6) covering partially the scientific domain (networks and telecoms). They are used to:

- propose to students (initial learners) partial or complete degree,
- answer to lifelong learning demands.

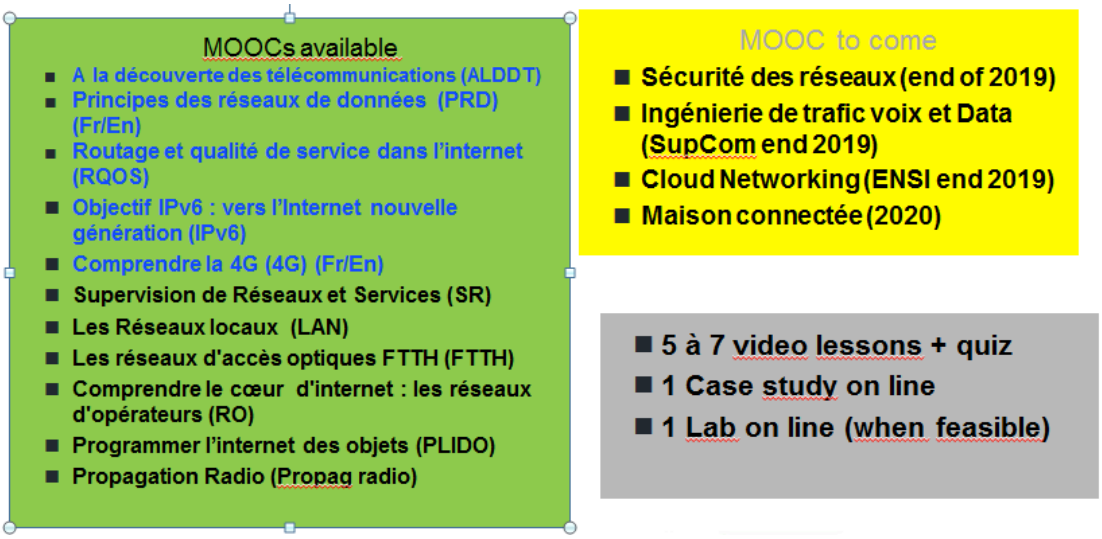


Figure 6 MOOCs list, MOOC abbreviations names used inside this paper are enclosed by ()

The course structure described in paragraph 2.1 provides valuable arguments to propose to learners either on line free access to knowledge or paid access to professional skills associated to a certificate delivery. For example, MOOC can propose a free access for video lectures and quizzes, while premium members can access case studies, labs and simulators

4.1. Standalone MOOC

4.1.1. Free MOOC sessions

Most MOOC have been broadcasted publically on FUN in French language. Pubic is 55% in France and 40 % in Africa (French speaking countries). We have observed that for the networks and telecoms domain, more than 60 % of enrolled learners are professional occupying a position. Among which 50% work in large companies and 50% in small or middle companies. The motivations expressed by these two groups are significantly different.

Large companies learners wish to obtain a better position, change of category.

SMEs and PMEs learners explain that they anticipate evolution business and want to keep their skills up to date. A comparison of different MOOC (Figure 7) exhibits significant differences according to pre-requisites level but the MOOC broadcasting period merits more attention. One can observe that in average 14.4% enrolled student begins, 65% of started becomes diligent. The diligent success rate is high 67.9%. Weak diligent success rate are typical of MOOCs difficulty. PRD requires a lot of work (6 to 7 hours per week), Propag-Radio assumes very good knowledge in Physic and targets master degree students also many enrolled mays have abandoned after pre-requisite quiz. Even when difficulty and pre-requisite are clearly presented in the MOOC description many learners enrolled.

MOOC name Targeted audience	Average	PRD_6 pre Bachelor	RO Bachelor	FTTH pre Bachelor	Propag radio post Bachelor	SR_1 Bachelor	SR-2 Bachelor	LAN_1 MOOC PRD	LAN_2 MOOC PRD
Enrolled		7267	10246	6250	4325	6352	6080	8313	5774
% started	14,4%	12,9%	22,0%	30,3%	6,0%	8,3%	8,4%	18,9%	8,5%
% diligent	9,3%	7,8%	14,0%	18,6%	2,8%	7,4%	7,2%	12,6%	4,3%
% success	6,5%	3,9%	8,9%	15,3%	1,1%	6,2%	5,7%	7,8%	3,4%
% diligent success	67,9%	49,4%	63,0%	84,9%	40,0%	85,0%	79,0%	62,0%	79,5%

Figure 7 Multi MOOC of the collection comparison

The average global perceived gain is 2 (Figure 8). The MOOC FTTH being an exception as student's prerequisite knowledge on the topic is low. MOOC Propag-Radio, even complex, achieves the second best gain.

	Average	PRD_6 pre Bachelor	PRD_7 pre Bachelor	PRD_8 pre Bachelor	RO MOOC PRD	FTTH pre Bachelor	Propag radio post Bachelo	SR_1 Bachelor	SR-2 Bachelor	LAN_1 MOOC PRD
Skill gain	2,46	2,38	1,71	1,78	2,02	5,35	2,68	2,11	2,30	1,81
Estimation before	4,46	3,92	3,91	4,17	5,53	2,68	5,35	4,61	4,54	5,43
Estimation after	6,92	6,30	5,62	5,95	7,55	8,03	8,03	6,72	6,84	7,24

Figure 8 Skill gain comparison

Collection impact on enrolment is important. A communication for each new MOOC (or MOOC session) is made to all enrolled students of other MOOCs in the collection. Important enrolment peaks are clearly and immediately visible.

We also measure dual enrolment in the MOOC of the collection. Figure 9 shows dual enrolment figures for MOOC RO session 1 (more than10 000 enrolment see Figure 7). The closer is the previous MOOC session, the more students enroll. On Figure 9 FTTH was 3 month before RO session. LAN and SR finished 6 month before. PRD6 took place one year before and more for PRD5

PRD5	PRD6	LAN	SR	FTTH
1239	1329	1929	1768	2465
12%	13%	19%	17%	24%

Figure 9 : Collection impact on enrollments, proportion of dual enrolments.

4.1.2. Certificate

The project has experimented on MOOC PRD (session 7 and 8) a freemium/premium proposal:

- DISCOVERY: free but provide access to reduce content, merely the theoretical contents.

- QUALIFYING: providing access to all content: knowledge, use and know how (as defined in parag 2.1), additional contents, on line bas (see parag 4) plus a proctored exam to obtain an IMT certificate. The price is 150€.

Qualifying Formula	Session 8	Sesion 7
Percentage of enrolled learners taking the « qualifing » offer".	0,4%	0,5%
% started	100%	80%
% diligent	80%	63%
% diligent certified	56%	70%
% certified	45%	44%

-

Figure 10 : Observed results in formula QUALIFYING

Figure 10 shows that surprisingly there is still a learner's proportion that does not even start while paying for additional content. Diligent proportion is much higher than in public MOOC (see Figure 7). And only 45% of them obtained the certificate, this is much less than in a classical teaching. Some learners did achieve a pretty good grade in the MOOC but did not make the proctored exam. Queried by mail all explained that they were not feeling self-confident. Achieving student self-confidence appears an on line course weakness. In a classroom, direct contact with other students and a teacher builds a better self-confidence. On line students work alone and barely use the forums to get help, even when they pay the course.

One can also observe on Figure 8 that from PRD6 (session 6) to PRD7 (session 7) the skill gain decreases. This corresponds to the fact that in PRD6 all students had access to the whole content (equivalent to QUALIFYING formula) while in PRD7 most had only access to DISCOVERY content. Self-skill evaluation appears consistent with accessible content reduction.

4.2. MOOC Programs

IMT offers several MOOC programs for developing skills step by step. IMT MOOCs are proposed in session mode (as opposed at self-paced or always available). These enables to provide support limited in time (teaching assistant during the session) and to control forum (avoid illegal usage). The drawback is that learners must do all the work during the session.

4.2.1. Networks MOOC program on FUN

A three MOOCs sequence in the domain "networks and telecommunication" has been planned so that learners can follow MOOC AALDT (January – February) then MOOC PRD (March –April) and then MOOC RQOS (May-June) Communication has been made on the sequence as a whole and not MOOC by MOOC. One can observe on Figure 11 that the common enrolment proportion is important and higher than observed on Figure 9. 15% have enrolled in the three MOOC.

	ALDDT	PRD8	RQOS6
NB enrolled	3364	3961	3671
Nb enolled common to ALDT and	**3364**	**1226**	**568**
% common enrolled	**100%**	**31%**	**15%**

Figure 11 Common enrolments in sequenced MOOC sessions

But if we look on "started" Figure 1(Figure 12) results are more disappointing. There is no obvious proof of student commonly started 2 MOOC increase. The proportion of starting student decreases from first MOOC to second and third. A possible explanation is that the broadcasting period is probably the most important criteria upon student availability to perform MOOC activities.

	ALDDT	PRD8	RQOS6
NB started	1112	867	445
% started	33%	22%	12%
Nb started common to ALDT and	**1112**	**194**	**40**
% started common	**100%**	**17%**	**4%**

Figure 12: Anlysis of started

4.2.2. "Networks basics" program with certificate

The program "Networks basics" composed of 4 on line courses (ALDDT, PRD, LAN and FTTH see Figure 6) is proposed with "Ecole Supérieure Polytechnique" (ESP) Dakar Senegal for 100 000 Fcfa (paid at ESP). Successful students obtain an IMT-ESP certificate. Student workload is evaluated to 150 hours. The program duration is one semester. It is planned to propose the program twice a year, for autumn semester and spring semester. It is Implemented as 4 SPOC (ie, not public MOOCs) on FUN campus platform.

Communication is made in newspapers and radio. ESP has enrolled 75 students in 2019 session. SPOCs were sequentially opened, one every month and remain opened until the end of the program. Weekly mail was sent to students in order to maintain their attention. Teaching assistants were available to answer to students questions but they had nearly no question on the forum.

Teaching assistant are quite passive and only react when triggered by learners. Conclusion is that teaching assistant should be more proactive as community managers and coaches to enhanced learners' interaction, sense of community and motivation.

Most students had difficulties to work regularly and the majority is quickly getting behind schedule. Finally only 14 students among 75 got the certificate.

4.3. Lifelong learning - Blended programs [4] – Hybrid MOOC[5]

Encouraged by observation about public MOOC professional audience (cf. parag 4.1.1) multiple marketing approaches have been experimented during the project by IMT lifelong learning service (Telecom Evolution TeV).

The initial business model was to sell programs based on several MOOCs associated with labs in physical spaces with IMT's equipment and a certificate. It appeared that 100 to 150 hours programs

do not respond market expectations: they are too heavy for companies and professionals who prefer short and modular trunks. Shorter modules have been set up such as a single course (SPOC) associated with a learner progress survey available to manager, a teaching assistant to answer to learners questions. An administrative person to enrolls learner and responds to technical issues (questions related to the platform). A dedicated platform that provides a completion process (learner must do sequentially the course) has been used. Even if this proposal got a very good feedback when proposed to companies the number of real customers remains low. The use of forum is also quite inexistent also it not worthwhile to pay for a learning assistant during a session if they act only in "reactive mode" and not as coaches. When a question related to the content and needing an expert appears, the administrative person relays it to a teacher. Learners' feedback was very positive but they expressed demands for hands on activities in physical workshops.

Also new offering are merely hybrid [6]. A one or two days session for practical activities (Lab, case studies) is proposed after the on line course.

Some courses are deployed in hybrid mode, mixing on line activities (mainly theoretical) in the form of MOOC or SPOC and hands on activities in physical spaces, such as labs.

Results are very encouraging in terms of

- Meeting market needs
- Revenue generation in a commercial approach
- Skill acquisition for learners
- Learners' satisfaction

As an example, a hybrid course on Internet of Thing has been deployed for professionals in march 2019.

Course was deployed during 3 days, mixing online activities and hands on activities in workshops.

13 trainees bought this course (1 900€).

100% were certified (based on online evaluation and workshop production)

- 100% were satisfied (35% very satisfied and 65 satisfied)

Feedback from learners was very positive

- They much appreciated the hybrid format – learn at their own pace, autonomy in their learning, flexibility to pick up areas of interest
- They appreciated the mix between theory and hands on activities, in group

Difficulties identified:

- As learners are progressing at different speeds, it is difficult to synchronize the whole group (e.g., sum up a chapter while some have finished long time ago and other not)

- For the same reason, difficulties to perform work in group
- Additional costs for blending the courses needed to
    - resources needed to manage on line content and access as compared to a traditional face to face training
    - resources needed to perform the workshops as compared to a 100% on line course

While online content is provided teacher is more focused on providing additional explanations, answering questions and supporting the hands on activities.

From a business model point of view, while the hybrid format seems to answer market and learners' expectations, the cost is the main issue as on line training is often perceived as a mean to decrease cost while in reality blended learning is more costly than 100% face to face or online training.[7]

5. On line Labs activities

MOOCs and SPOCs of the collection include labs using simulators to be installed on the learners' computer. This raises multiple difficulties.

- Simulators works only on computers. This eliminates learners on Mobile phone and tablets.
- Simulator installation is only possible by learners that administrate personally their computer. This is not the case in many companies.
- Installation requires computer science skills that are outside the prerequisite of the course. Very often installation errors or parameters settings build incorrect lab configuration.
- Some computers are not powerful enough to support the simulators (slow CPU, not enough memory…).
- Teachers must provide installation description and files for the different existing computers and operating systems (Macintosh, PC, Unix, Linux…). Providing a virtual machine to be installed may make this simpler but files to upload are huge. These issues represent nearly 30% of the post in the forum.
- There is no way to observe learner progress or behavior during their lab activity. Answers to quizzes are proposed in the course but any mistake in lab configuration by student leads to erroneous answer. Helping student need screens copy on the forum, and many interactions.

Consequently a significant effort has been made by the project to provide on line lab access (simulators hosted on a remote server in the Cloud) specifically to allow professional learners to perform lab from their company and to avoid students to have to master computer sciences skills. Solution developed by Procan company (FLIRT project partner) is to perform lab hosted in a Cloud server with all interaction in a learner browser screen. Teachers configure once the virtual machine in the cloud so those learners don't have to do it. Learners have just to click on a link inside the course to access the lab environment in a browser window. This solution is accepted by most company firewall.

Virtual machine inside the cloud is not free, so this solution can be used only with the QUALIFYING formula described in parag 4.1.2. to cover this cost.

This solution significantly reduces teaching assistant support. The VM in the cloud is selected so as to be enough powerful so that lab environment is more convenient.

With this solution, teachers can see what is done in real time by learners. This opens an opportunity to enrich commercial offering.

6. Conclusion

Course collection availability opens the opportunity to propose coherent learning programs and experiment lifelong learning offering and business model.

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